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Adsorption and desorption behavior of zinc oxide nanoparticles at the soil-water interface using standardized soil LUFA 2.2 and 2.3

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Abstract

The use of engineered nanomaterials (ENM) is increasing. Especially, zinc oxide nanoparticles (ZnO NP) are now widely used in a range of consumer goods e.g. car tires, sunscreens and catalysts for various processes. The increasing use will inevitably result in ENM being released to the environment. One release pathway could be to soils through e.g. biosolids. While much attention has been on aquatic exposure less is known about the behavior of ENM in soils. Especially, the adsorption and desorption properties of ENM onto different soil types are lacking. In this study, the OECD guideline 106 for adsorption and desorption was used to evaluate the behavior of ZnO NP in two different standardized soils. The standardized soils tested were LUFA 2.2 and 2.3. The applied concentration was 3.35 mg Zn/L and samples were taken at 2, 4, 6 and 24 hours. The ZnO NP had a primary particle size of 35 nm and was characterized by ICP-MS, DLS, BET and TEM.
During the test a very rapid adsorption of the ZnO NP was observed on both soils reaching equilibrium within the first two hours of the test. The equilibrium concentration was found to be 2.02±0.2 mg Zn/L and 0.29±0.10 mg Zn/L for LUFA 2.2 and LUFA 2.3 respectively. The adsorption capacity was found to be 389.5 L/kg and 177.97 L/kg for LUFA 2.2 and LUFA 2.3 respectively. The adsorbed ZnO NP desorped rapidly within the first 6 hours of exposure to clean media. At 24 hours the desorbed fraction could not be determined statistically different from 6 hours. Consequently, it was proposed that the remaining Zn was bound as inner-sphere complexes. The linearized Freundlich adsorption isotherm was fitted to the data and it was observed that the adsorbed amount of Zn increased with increasing concentrations. For the desorption isotherm it was found that the rate of desorption increased more than the adsorption with increasing concentrations.

Keywords: Adsorption, desorption, soil, zinc oxide nanoparticles